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Summary

Four ruminally and duodenally fistulated steers were utilized to evaluate the effects of Syngenta Enhanced Feed Corn™ containing an alpha amylase enzyme trait (SYT-EFC) compared to the isoline parental control corn without the alpha amylase enzyme trait (Negative Isoline) on site and extent of digestion in finishing diets. Cattle fed SYT-EFC dry rolled corn had numerically greater postruminal starch digestibility, excreted lower fecal starch, and had greater total tract starch digestibility compared to cattle fed Negative Isoline corn. These data would suggest that cattle are able to utilize more starch from corn containing the SYT-EFC trait, which has resulted in greater gains and efficiencies.

Introduction

Additional growth technologies are needed by the beef industry to improve feed conversion. Three experiments have been conducted to evaluate the effect of feeding SYT-EFC on finishing cattle performance (*2016 Nebraska Beef Report* pp. 135; *2016 Nebraska Beef Report* pp. 143). When cattle were fed SYT-EFC dry rolled corn with byproducts; feeding value increased by 101 to 115% over the control. With the data from the finishing trials, the hypothesis of this digestion experiment was that more starch is being digested by cattle fed SYT-EFC corn compared to corn without the alpha amylase enzyme trait. Therefore, the objective of this trial was to evaluate the effect of feeding SYT-EFC corn containing the alpha amylase enzyme trait on site and extent of digestion and ruminal metabolism characteristics.

Procedure

A metabolism experiment was conducted to evaluate the effects of feeding SYT-EFC dry rolled corn (Syngenta Seeds, Inc.) on site and extent of digestion in finishing diets. The corn utilized in this trial was grown at the UNL Agricultural Research and Development Center (ARDC) near Mead, NE and contained the alpha amylase enzyme trait (SYT-EFC) or was the near isoline, parental corn hybrid that did not contain the trait (Negative Isoline, NEG). The trial utilized 4 ruminally and duodenally cannulated steers in a 4 steer, 6 period row-column transformation design. Steers were assigned randomly to treatments by utilizing a row by column random number arrangement. Dietary treatments (Table 1) were designed in a 2 × 2 + 1 factorial arrangement. The first factor was corn trait, which consisted of SYT-EFC or Negative Isoline corn. The second factor consisted of byproduct type, being either modified distillers grains plus solubles (MDGS) or sweet bran (SB). Lastly, the plus one treatment consisted of a 50:50 blend of SYT-EFC and NEG corn with MDGS (BLEND). All diets contained 360 mg/steer daily of Rumensin (30 g/ton of DM) and 90 mg/steer daily of tylosin (9 g/ton of DM).

Table 1. Diet Composition on a DM basis fed to finishing steers

Ingredient, % of DM	MDGS[a]			Sweet Bran	
	NEG[b]	SYT-EFC[b]	Blend	NEG[b]	SYT-EFC[b]
SYT-EFC DRC[c]	—	65	32.5	—	55
Negative Isoline DRC[c]	65	—	32.5	55	—
MDGS[a]	15	15	15	—	—
Sweet Bran	—	—	—	25	25
Corn Silage	15	15	15	15	15
Supplement[d]	5	5	5	5	5
Fine ground corn	2.11	2.11	2.11	2.76	2.76
Limestone	1.67	1.67	1.67	1.63	1.63
Urea	0.63	0.63	0.63	0.10	0.10
Salt	0.3	0.3	0.3	0.3	0.3
Tallow	0.125	0.125	0.125	0.125	0.125
Trace mineral premix	0.05	0.05	0.05	0.05	0.05
Potassium chloride	0.064	0.064	0.064	—	—
Rumensin-90	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin ADE premix	0.015	0.015	0.015	0.015	0.015
Tylan-40	0.01	0.01	0.01	0.01	0.01
Analyzed Composition, %					
OM	95.8	95.5	95.6	95.1	94.8
CP	15.5	15.4	15.4	14.7	14.7
Starch	54.5	52.4	53.5	50.7	48.9

[a]MDGS = Modified distillers grains plus solubles
[b]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[c]DRC = Dry rolled corn
[d]Formulated to contain 360 mg/steer daily of Rumensin and 90 mg/steer daily of Tylan

Table 2. Effects of corn trait and byproduct type in finishing diets on nutrient intake, flow, and digestion

Item	Dietary Treatments					SEM	2 × 2[b]				Contrasts[c]		
	MDGS[a]			Sweet Bran									
	NEG[d]	SYT-EFC[d]	Blend	NEG[d]	SYT-EFC[d]		F-Test[e]	Trait	Byproduct	Int.	SYT-EFC vs. NEG	NEG vs. Blend	SYT-EFC vs. Blend
Intake, lb/d													
DM	16.7	17.2	18.1	19.6	17.6	1.4	0.12	0.33	0.04	0.09	0.59	0.28	0.50
OM	15.9	16.5	17.3	18.6	16.7	1.3	0.13	0.36	0.05	0.08	0.54	0.27	0.52
Starch	8.8	9.4	9.7	9.7	8.9	0.7	0.40	0.87	0.60	0.09	0.28	0.19	0.65
Ruminal Digestibility, %													
Apparent OM	50.29	54.99	49.65	55.54	53.98	2.82	0.30	0.48	0.36	.017	0.16	0.87	0.17
True OM[f]	56.02	59.71	56.43	61.82	59.76	2.60	0.31	0.68	0.19	0.18	0.22	0.91	0.35
Apparent Starch	77.21	82.80	74.56	79.82	77.43	3.40	0.33	0.54	0.60	0.14	0.16	0.57	0.08
True Starch[g]	77.62	83.11	75.03	80.37	78.97	3.39	0.37	0.43	0.79	0.20	0.16	0.57	0.08
Postruminal Digestibility, % Entering													
OM	52.99	58.06	58.95	47.90	61.02	6.08	0.32	0.08	0.83	0.40	0.46	0.49	0.91
Starch	55.63	61.50	75.25	51.89	72.50	10.67	0.25	0.11	0.65	0.35	0.61	0.18	0.31
Fecal Output, lb/d													
OM	3.43	3.19	3.41	4.31	2.95	0.23	0.18	0.05	0.42	0.16	0.65	0.96	0.71
Starch	0.804[hi]	0.679[ij]	0.662[ij]	1.06[h]	0.477[j]	0.088	0.06	0.01	0.82	0.08	0.48	0.45	0.93
Total-Tract Digestibility, %													
DM	75.39	79.32	78.79	75.96	81.41	2.71	0.29	0.05	0.55	0.72	0.21	0.38	0.88
OM	76.38	80.68	79.92	77.11	82.47	2.64	0.26	0.04	0.56	0.80	0.17	0.35	0.83
Starch	90.41[ij]	92.79[hij]	93.67[hi]	89.69[j]	94.72[h]	1.94	0.09	0.02	0.66	0.33	0.24	0.19	0.70

[a]MDGS = Modified distillers grains plus solubles
[b]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[c]SYT-EFC vs. NEG = MDGS SYT-EFC vs. NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; SYT-EFC vs. Blend = MDGS SYT-EFC vs. MDGS Blend
[d]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[e]F-Test = F-Test statistic for the effect of treatment
[f]True OM = Corrected for microbial OM reaching the duodenum
[g]True Starch = Corrected for microbial starch
[h,i,j]Means within a row with unlike superscripts differ ($P \leq 0.10$)

Steers were fed once daily at 0800 h and had ad libitum access to feed and water. Cattle were housed in individual, rubber slatted pens in a temperature controlled room. Ingredient samples were taken during the collection period at time of mixing, composited by period, and ground through a 1-mm screen of a Willey Mill. Period duration was 21-d with a 16-d adaptation phase and 5-d collection period. Beginning on d 10 of each period, titanium dioxide was dosed intraruminally at 0800 and 1600 h to provide a total of 10 g/d. Fecal and duodenal samples were collected 4 times/d at 0700, 1100, 1500, and 1900 h on d 17–20. Fecal samples were composited by day, freeze dried, ground through a Wiley Mill using a 1 mm screen, and composited by animal within period. Duodenal samples were freeze dried, ground as described previously, and composited by animal within period. Fecal and duodenal samples were analyzed for titanium dioxide to determine nutrient digestibility and duodenal flow. Feed ingredients, fecal, and duodenal samples were also analyzed for DM, OM, total starch, and CP.

On d 21, whole rumen contents were collected, fixed with formalin, and stored frozen at −4°C. At the conclusion of the trial, whole rumen contents were blended, strained through 3 layers of cheesecloth, centrifuged to isolate bacteria, and freeze dried. Bacteria isolates and duodenal contents were analyzed for purine concentration to determine microbial flow. Along with whole rumen contents, rumen fluid samples were collected using the suction-strainer technique on d 21. Rumen fluid samples were collected 5 times/d at 0700, 1000, 1300, 1600, and 1900 h. Samples were stored frozen until analyzed for ruminal volatile fatty acid (VFA) concentration. Ruminal pH was measured continuously from d 17 to 21 with submersible wireless pH probes. Measurements for pH included average ruminal pH, minimum and maximum pH, magnitude of change, variance, and time and area below 5.6.

All data were analyzed using the MIXED procedure of SAS with steer within

Table 3. Effects of corn trait and byproduct type in finishing diets on ruminal pH

Item	Dietary Treatments							2 × 2[b]			Contrasts[c]		
	MDGS[a]			Sweet Bran									
	NEG[d]	SYT-EFC[d]	Blend	NEG[d]	SYT-EFC[d]	SEM	F-Test[e]	Trait	Byproduct	Int.	SYT-EFC vs. NEG	NEG vs. Blend	SYT-EFC vs. Blend
Average pH	5.59	5.65	5.60	5.62	5.58	0.14	0.99	0.94	0.82	0.67	0.69	0.95	0.76
Maximum pH	6.47	6.47	6.52	6.42	6.38	0.09	0.70	0.87	0.24	0.59	0.94	0.59	0.64
Minimum pH	4.97	4.93	4.89	4.97	4.97	0.10	0.95	0.80	0.85	0.79	0.71	0.53	0.78
pH magnitude	1.51	1.53	1.63	1.45	1.40	0.09	0.45	0.98	0.20	0.44	0.86	0.35	0.44
pH variance[f]	0.150[mn]	0.153[mn]	0.207[n]	0.133[m]	0.099[m]	0.026	0.08	0.49	0.06	0.19	0.93	0.11	0.13
Time < 5.6, min/d[g]	802	790	803	777	750	174	0.99	0.93	0.91	0.99	0.96	0.99	0.95
Area <5.6, min/d[h]	289	287	290	247	300	104	0.99	0.80	0.97	0.85	0.99	0.99	0.98
Time < 5.3, min/d[i]	623	526	451	424	451	139	0.74	0.30	0.12	0.65	0.58	0.35	0.69
Area < 5.3, min/d[j]	143	109	82	86	117	49.6	0.85	0.30	0.19	0.47	0.60	0.38	0.70
Time < 5.0, min/d[k]	205	120	102	125	222	78.4	0.66	0.24	0.54	0.13	0.42	0.36	0.87
Area < 5.0, min/d[l]	23.6	13.5	8.2	16.3	34.0	15.4	0.76	0.22	0.59	0.31	0.64	0.51	0.82

[a]MDGS = Modified distillers grains plus solubles
[b]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[c]SYT-EFC vs. NEG = MDGS SYT-EFC vs. NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; SYT-EFC vs. Blend = MDGS SYT-EFC vs. MDGS Blend
[d]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[e]F-Test = F-Test statistic for the effect of treatment
[f]Variance of daily ruminal pH
[g]Time < 5.6 = Minutes that ruminal pH was below 5.6
[h]Area < 5.6 = Ruminal pH units below 5.6 by minute
[i]Time < 5.3 = Minutes that ruminal pH was below 5.6
[j]Area < 5.3 = Ruminal pH units below 5.3 by minute
[k]Time < 5.0 = Minutes that ruminal pH was below 5.0
[l]Area < 5.0 = Ruminal pH units below 5.0 by minute
[m,n]Means within a row with unlike superscripts differ ($P \leq 0.10$)

period as the experimental unit. Treatment and period were included in the model as fixed effects while steer was treated as a random effect for all analyses. The main effect of corn trait, byproduct type, and the interaction between corn trait and byproduct type were analyzed. An F-test was utilized to compare the means of all five treatments. Lastly, 3 pre-planned contrasts were used to evaluate the effect of corn trait when fed with MDGS. Treatment differences were considered significant at $P < 0.10$.

Results

Intake and Digestion

A corn trait by byproduct type interaction was observed for DMI, OMI, and starch intake ($P = 0.09$, 0.08, and 0.09; respectively; Table 2). Steers that consumed MDGS with SYT-EFC had greater DM, OM, and starch intakes than steers fed MDGS with NEG corn. However, the opposite was true when steers were fed Sweet Bran. Intakes were greater for steers fed Sweet Bran with NEG corn compared to SYT-EFC. No interactions for ruminal apparent OM, true OM, apparent starch or true starch digestibility ($P \geq 0.14$) were observed. There were no differences for the main effect of corn trait ($P \geq 0.43$) or byproduct type ($P \geq 0.19$) for ruminal apparent OM, true OM, apparent starch or true starch digestibility. There were no interactions observed for postruminal OM and starch digestion ($P \geq 0.35$). The main effect of corn trait was significant ($P = 0.08$) for postruminal OM digestibility and tended ($P = 0.11$) to be significant for postruminal starch digestion. There appears to be a biological difference between cattle fed SYT-EFC compared to NEG corn. Cattle that were fed SYT-EFC corn had a postruminal starch digestibility of 67.00% compared to 53.76% for cattle fed NEG corn. An interaction was observed for starch output ($P = 0.08$) with steers fed NEG with Sweet Bran having the greatest fecal starch excreted, NEG and SYT-EFC with MDGS were intermediate, and SYT-EFC with Sweet Bran had the lowest. Cattle that were fed SYT-EFC corn had less starch excreted in the feces compared to cattle fed NEG corn ($P = 0.01$). This resulted in cattle that were fed SYT-EFC corn having a greater total tract starch digestibility compared to steers fed NEG corn, 93.8% and 90.1%, respectively ($P = 0.02$). No interactions were observed for total tract DM or OM digestibility ($P \geq 0.72$). The main effect of trait was significant for total tract DM ($P = 0.05$) and OM ($P = 0.04$) digestibility with steers fed SYT-EFC having greater DM and OM digestibilities compared to NEG corn.

When comparing only the three diets that contain MDGS, there were no differences ($P \geq 0.19$) in DMI, OMI, or starch intake among steers fed SYT-EFC, NEG or BLEND (Table 2). However, cattle that were

Table 4. Effects of corn trait and byproduct type in finishing diets on volatile fatty acid profile

Item	Dietary Treatments[a]					SEM	F-Test[b]	2 × 2[c]			Contrasts[d]		
	MDGS NEG	MDGS EFC	MDGS Blend	SB NEG	SB EFC			Trait	Byproduct	Int.	EFC vs. NEG	NEG vs. Blend	EFC vs. Blend
Acetate, mol/100 mol	49.4	48.7	48.4	47.9	50.0	1.5	0.77	0.84	0.93	0.27	0.65	0.54	0.88
Propionate, mol/100 mol	35.6	37.0	36.8	37.5	33.8	2.1	0.59	0.60	0.63	0.13	0.58	0.63	0.94
Butyrate, mol/100 mol	10.2	10.0	10.7	10.0	10.8	0.8	0.91	0.59	0.86	0.37	0.85	0.69	0.55
Acetate:-Propionate	1.58	1.45	1.43	1.36	1.60	0.12	0.33	0.79	0.88	0.04	0.33	0.26	0.87
Total, mM	102.2[e]	107.1[e]	119.2[ef]	135.0[f]	106.0[e]	11.6	0.03	0.08	0.02	0.02	0.66	0.14	0.29

[a]MDGS NEG = Modified distillers grains plus solubles with parental Negative Isoline hybrid , MDGS EFC = Modified distillers grains plus solubles with SYT-EFC hybrid, MDGS Blend = Modified distillers grains plus solubles with 50:50 blend of EFC and NEG hybrids, SB NEG = Sweet Bran with parental Negative Isoline hybrid, SB EFC = Sweet Bran with SYT-EFC hybrid
[b]F-Test = F-Test statistic for the effect of treatment
[c]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[d]EFC vs. NEG = MDGS EFC vs. MDGS NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; EFC vs. Blend = MDGS EFC vs. MDGS Blend
[e,f]Means within a row with unlike superscripts differ ($P \leq 0.10$)

fed NEG corn had numerically lower DMI, OMI, and starch intake compared to SYT-EFC and BLEND. There were no differences ($P \geq 0.16$) for ruminal apparent and true OM among the three treatments. A tendency ($P = 0.16$) was observed for steers fed SYT-EFC to have greater ruminal apparent and true starch digestibilities compared to NEG. However, steers fed SYT-EFC corn did have greater ruminal apparent and true starch digestibilities compared to BLEND (P = 0.08). No differences were observed for OM and starch postruminal digestibilities ($P \geq 0.18$) or the amount of fecal OM and starch excreted ($P \geq 0.45$) for all three treatments. Although not significant, a numerical increase in postruminal starch digestion was observed for cattle fed SYT-EFC and BLEND compared to NEG corn. Fecal starch output followed a similar trend, with cattle fed SYT-EFC and BLEND having lower fecal starch than NEG corn. Among the three treatments, DM, OM, and starch total tract digestibilities were not different (P ≥ 0.17). However, cattle fed SYT-EFC with MDGS had numerically greater DM, OM, and starch total tract digestibility than NEG.

Ruminal pH

There were no interactions ($P \geq 0.44$), effect of corn trait ($P \geq 0.80$), or effect of byproduct ($P \geq 0.20$) observed for average, maximum, minimum, or magnitude of pH change (Table 3). There were no interactions ($P \geq 0.13$), effect of trait ($P \geq 0.22$) or effect of byproduct ($P \geq 0.12$) observed for time and area below 5.6, 5.3, or 5.0. No differences were observed among the 3 treatments that contained MDGS for all ruminal pH characteristics ($P \geq 0.11$).

VFA Concentration

There were no interactions ($P \geq 0.13$), effect of corn trait ($P \geq 0.59$), or effect of byproduct ($P \geq 0.63$) observed for the ruminal VFA proportions of acetate, propionate, and butyrate (Table 4). An interaction was observed ($P = 0.04$) for the acetate to propionate (A:P) ratio. Steers fed SYT-EFC with MDGS had a lower A:P ratio compared to NEG with MDGS (1.45 and 1.58, respectively). Conversely, cattle that were fed Sweet Bran with SYT-EFC had a higher A:P ratio compared to NEG with Sweet Bran (1.60 and 1.36, respectively). One explanation for the interaction could be that when SYT-EFC corn is fed with MDGS a slight shift in propionate production from acetate occurs. Whereas, when SYT-EFC is fed with Sweet Bran starch digestion bypasses the rumen and is utilized in the intestine. No differences were observed among the three treatments that contained MDGS for all VFA characteristics ($P \geq 0.14$).

These data suggest that cattle fed SYT-EFC corn have increased postruminal and total tract starch digestion compared to cattle fed Negative Isoline corn. When steers utilize an energy source to a greater extent it will result in increased gains and efficiencies which corresponds with our finishing data. Syngenta Enhanced Feed Corn would be best suited for producers who have the ability to manage the source (hybrid) of corn fed to their cattle.

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